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13. ABSTRACT (Maximum 200 words)

This report covers the period August 1st to August 31st, 2002, while I was working for Boston University (BU). On September 1st, I transferred to Rensselaer Polytechnic Institute (RPI). It is my understanding that this report is required for the transfer of the contract from BU to RPI.

The reflective properties of a triple-layer omni-directional reflector have been investigated. The reflector has a two-fold purpose, namely it serves as ohmic contact to the top GaN layer of a UV LED and also as a reflector. The reflector consists of the semiconductor (GaN), indium tin oxide (ITO), and a metal layer. It was found that the reflector has reflectivities exceeding 90 % for all angles of incidence. Such highly reflective ohmic contacts are desirable as conventional ohmic contacts represent a major loss mechanism in UV LEDs.

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Date: Feb 10, 2003

Report on ARO / DARPA contract entitled: Ultraviolet-spectrum light-emitting diodes with omnidirectional reflectors for high extraction efficiency

PI: E. Fred Schubert
ARO grant number: ARO#DAAD190210320
BU grant number: BU 9626-5
RPI grant number: Not yet issued

This report covers the period August 1st to August 31st, 2002, while the PI was working for Boston University (BU). On September 1st, the PI transferred to Rensselaer Polytechnic Institute (RPI). The PI understands that this report is required for the transfer of the contract/grant from BU to RPI.

Introduction:
Ultraviolet light-emitting diodes (UV-LEDs) are instrumental for systems allowing the non-contact optical detection of aerosol biological and chemical agents. In such detection systems, UV-LEDs are used for optical excitation. The optical emission resulting from the photo-excitation is analyzed and harmful agents identified. In addition, UV-LEDs offer new modes of wireless photonic communication operating in the solar-blind UV regime that rely on scattering. This wavelength regime is not subject to significant solar radiation so that UV source power levels can be much lower compared with IR photonic wireless systems.

The work performed under the contract at Boston University in August 2002 concentrated on highly reflective ohmic contacts for UV LEDs based on triple-layer reflectors.

Work performed:
It is highly desirable to demonstrate highly reflective ohmic contacts to p-type GaN. In UV LEDs grown in a p-side up configuration on sapphire, the light emitted by the active region is generated under the top p-type contact. If this contact possesses low reflectivity, significant optical losses occur. The common NiAu contacts have reflectivities of < 50 % after annealing. Other contacts, including Pt-, Pd-, ITO-, and a Ag-based contacts have also been demonstrated. We have investigated the properties of ***triple-layer reflector/contacts***.

The triple-layer reflector has a two-fold purpose, namely it serves as ohmic contact to the top GaN or AlGaN layer of a UV LED and also as a reflector. High reflectivity and omni-directionality are desirable. The new type of reflector investigated under the current program consists of the semiconductor (GaN), indium tin oxide (ITO), and a metal layer. The optical properties of triple-layer reflectors with Au and Ag metals have been calculated and investigated. The reflectivity of the triple-layer reflector was calculated for angles of incidence ranging from normal incidence (0 °) to 90 °. It was found that the triple-layer reflector has reflectivities exceeding 90 % for all angles of incidence. Such highly reflective ohmic contacts are desirable.

Subsequently, LEDs emitting in the blue have been fabricated with the triple-layer reflective contact. The devices show a clear increase in optical output power when compared to conventional NiAu contacts fabricated from the same wafer.

Additional information:
Our laboratory facilities are currently being re-established at RPI. This process is expected to be completed in about 2 months.